Unit-Level Variations in Healthcare Professionals' Availability for Preterm Neonates <29 Weeks' Gestation: An International Survey

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Abstract: INTRODUCTION The availability of and variability in healthcare professionals in neonatal units in different countries has not been well characterized. Our objective was to identify variations in the healthcare professionals for preterm neonates in 10 national or regional neonatal networks participating in the International Network for Evaluating Outcomes (iNeo) of neonates. METHOD Online, pre-piloted questionnaires about the availability of healthcare professionals were sent to the directors of 390 tertiary neonatal units in 10 international networks: Australia/New Zealand, Canada, Finland, Illinois, Israel, Japan, Spain, Sweden, Switzerland, and Tuscany. RESULTS Overall, 325 of 390 units (83%) responded. About half of the units (48%; 156/325) cared for 11-30 neonates/day and had team-based (43%; 138/325) care models. Neonatologists were present 24 h a day in 59% of the units (191/325), junior doctors in 60% (194/325), and nurse practitioners in 36% (116/325). A nurse-to-patient ratio of 1:1 for infants who are unstable and require complex care was used in 52% of the units (170/325), whereas a ratio of 1:1 or 1:2 for neonates requiring multisystem support was available in 59% (192/325) of the units. Availability of a respiratory therapist (15%, 49/325), pharmacist (40%, 130/325), dietitian (34%, 112/325), social worker (81%, 263/325), lactation consultant (45%, 146/325), parent buddy (6%, 19/325), or parents' resource personnel (11%, 34/325) were widely variable between units. CONCLUSIONS We identified variability in the availability and organization of the healthcare professionals between and within countries for the care of extremely preterm neonates. Further research is needed to associate healthcare workers' availability and outcomes.

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Unit-Level Variations in Healthcare Professionals' Availability for Preterm Neonates <29 Weeks' Gestation: An International Survey

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Keywords
Neonatologist · Nurse · Respiratory therapist · Pharmacist · Dietitian · Preterm infant · Neonate

A full list of iNeo Investigators is provided in the online supplementary material.

Abstract
Introduction: The availability of and variability in healthcare professionals in neonatal units in different countries has not been well characterized. Our objective was to identify variations in the healthcare professionals for preterm neonates in 10 national or regional neonatal networks participating in the International Network for Evaluating Outcomes (iNeo) of neonates. ***Method:*** Online, pre-piloted questionnaires about

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the availability of healthcare professionals were sent to the directors of 390 tertiary neonatal units in 10 international networks: Australia/New Zealand, Canada, Finland, Illinois, Israel, Japan, Spain, Sweden, Switzerland, and Tuscany. ***Results:*** Overall, 325 of 390 units (83%) responded. About half of the units (48%; 156/325) cared for 11–30 neonates/day and had team-based (43%; 138/325) care models. Neonatologists were present 24 h a day in 59% of the units (191/325), junior doctors in 60% (194/325), and nurse practitioners in 36% (116/325). A nurse-to-patient ratio of 1:1 for infants who are unstable and require complex care was used in 52% of the units (170/325), whereas a ratio of 1:1 or 1:2 for neonates requiring multisystem support was available in 59% (192/325) of the units. Availability of a respiratory therapist (15%, 49/325), pharmacist (40%, 130/325), dietitian (34%, 112/325), social worker (81%, 263/325), lactation consultant (45%, 146/325), parent buddy (6%, 19/325), or parents' resource personnel (11%, 34/325) were widely variable between units. ***Conclusions:*** We identified variability in the availability and organization of the healthcare professionals between and within countries for the care of extremely preterm neonates. Further research is needed to associate healthcare workers' availability and outcomes.

Introduction

Neonates admitted to neonatal intensive care units (NICUs) have complex care needs and require high levels of resources and organization [1, 2]. Advances in perinatal and neonatal care, especially in high-income countries, have led to significant improvements in mortality and morbidity [3, 4]. However, marked variations in neonatal outcomes were identified between networks participating in the International Network for Evaluating Outcomes (iNeo) of neonates [5]. The iNeo is a multinational collaboration of population-based national neonatal networks that provides a platform for comparative evaluation of outcomes and processes of care of extremely preterm neonates and very low birth weight neonates at national and individual unit level [6, 7].

Variations in neonatal outcomes could be due to differences between patient populations, clinical practices, definitions, data collection processes, healthcare service organization, physical factors, and the availability of healthcare professionals at a unit, regional, or national level [6]. While population characteristics and clinical practice variations are adjusted for in analyses to explain the impact of these variables on neonatal outcomes, they do not explain all outcome differences between units, regions, or countries. In particular, a limited number of previous studies have evaluated the variations in the availability of healthcare professionals between neonatal units. In this study, our objective was to report the results of a survey conducted to identify variations in unit-level healthcare professionals' availability for preterm neonates <29 weeks' gestation among 10 iNeo networks.

Materials and Methods

Study Design and Population

Online, pre-piloted questionnaires on the management of neonates born at <29 weeks' gestation were sent to the directors of 390 tertiary NICUs in 10 collaborating networks from 11 countries. This included 9 neonatal networks participating in iNeo from 10 countries (ANZNN includes 2 countries; Australia and New Zealand) and the Illinois Neonatal Network (which joined the iNeo collaboration for the purpose of survey responses at this time): Australia/New Zealand (ANZNN, $n = 28$); Canada (CNN, $n = 30$); Finland (FinMBR, $n = 5$); Illinois, USA (ILNN, $n = 18$); Israel (INN, $n = 26$); Japan (NRNJ, $n = 204$); Spain (SEN1500, $n = 57$); Sweden (SNQ, $n = 6$); Switzerland (SwissNeoNet, $n = 12$), and Tuscany, Italy (TuscanNN, $n = 4$). All units were level 3 or mixed-level 2/3 units and provided care for neonates born at <29 weeks. The entire questionnaire included 68 questions, none of which were mandatory, and respondents were instructed to provide answers reflecting their unit practice/protocols in 2015, and not personal preferences. The survey commenced in August 2016 and closed in December 2016. During the pilot phase, network directors and select unit directors were asked to complete the questionnaire and suggest changes to improve clarity and content.

The questions relevant to healthcare professionals' availability queried the average daily census of patients (1 question); model of care in the unit (1 question); availability of healthcare professionals round the clock every day or during weekdays, week nights, or weekends (1 question); nurse-patient assignment ratio based on the intensity of required care (1 question), and type of dedicated personnel for specialty roles (1 question; online suppl. Appendix 1; see www.karger.com/doi/10.1159/000501801 for all online suppl. material). For questions related to nurse-to-patient ratio, we used the American Academy of Pediatrics (AAP) suggested ratios as the reference [8], which included newborns requiring continuing care (1 nurse: 3–4 patients), intermediate care (1 nurse: 2–3 patients), intensive care (1 nurse: 1–2 patients), multisystem support (1 nurse: 1 patient), unstable newborns requiring complex critical care (1 nurse: 1 patient), or greater. We used ratios that were equal to or higher than the recommended ratio, meaning that there were more nurses for patients, as meeting requirements. When the nurse-to-patient ratio was lower than recommended, meaning that there were fewer nurses for patients according to their requirement of care needs, it was defined as not meeting the criteria.

Data Analysis

Data are reported using descriptive statistics. No comparisons were made between units or countries.

Table 1. Daily volume of neonates and models of care delivery

	ANZNN (*n* = 27)	CNN (*n* = 30)	FinMBR (*n* = 5)	ILNN (*n* = 15)	INN (*n* = 26)	NRNJ (*n* = 155)	SEN1500 (*n* = 46)	SNN (*n* = 11)	SNQ (*n* = 6)	Tuscan NN (*n* = 4)	Total (*n* = 325)
Neonates per day											
<10	0 (0)	1 (3)	0 (0)	0 (0)	3 (12)	36 (23)	25 (54)	1 (10)	0 (0)	1 (25)	67 (21)
11–30	8 (30)	14 (45)	5 (100)	6 (38)	13 (51)	81 (52)	15 (33)	7 (60)	4 (67)	3 (75)	156 (48)
31–50	12 (44)	11 (38)	0 (0)	8 (50)	5 (19)	31 (20)	4 (8)	3 (30)	2 (33)	0 (0)	76 (23)
>51	7 (26)	4 (14)	0 (0)	2 (12)	2 (8)	8 (5)	2 (5)	0 (0)	0 (0)	0 (0)	25 (8)
Model of care delivery											
Team based	21 (78)	26 (87)	1 (20)	14 (93)	21 (81)	30 (19)	10 (22)	7 (64)	4 (67)	4 (100)	138 (43)
Individual neonatologist	1 (4)	1 (3)	0 (0)	0 (0)	0 (0)	31 (20)	16 (35)	0 (0)	0 (0)	0 (0)	49 (15)
Combination of above	4 (15)	3 (10)	4 (80)	1 (7)	4 (15)	94 (61)	20 (44)	4 (36)	2 (33)	0 (0)	136 (42)
Other	1 (4)	0 (0)	0 (0)	0 (0)	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (1)

Data are presented as *n* (%). ANZNN, Australia/New Zealand; CNN, Canada; FinMBR, Finland; ILNN, Illinois; INN, Israel; NRNJ, Japan; SEN1500, Spain; SNN, Switzerland; SNQ, Sweden; Tuscan NN, Tuscany; *n*, number of units in the network.

Research Ethics Approval

Participating networks received ethics/regulatory approval from their local granting agencies following the iNeo protocol. Specific approval for this project was obtained from the Research Ethics Board at Mount Sinai Hospital (Toronto, ON, Canada) where the coordination of the project was conducted. The responders were asked to complete the survey only if they provided consent for data assimilation and reporting.

Results

Overall, 325 of 390 (83%) neonatal units in 10 collaborating networks responded to some or all of the questions in the questionnaire, with a response rate varying between 67 and 100% of units among the networks.

Volume of Patients (All Gestational Ages Included)

The volume of neonates was classified into 4 categories (Table 1). The majority of units (48%; 156/325) cared for 11–30 neonates daily, ranging from 30% of units (8/27) in Australia/New Zealand to 100% in Finland (5/5). Approximately 23% of units (76/325) cared for 31–50 neonates daily, ranging from 8% in Spain (4/46) to 50% in Illinois (8/15). Interestingly, >50% of NICUs in Australia/New Zealand, Canada, and Illinois have a daily census of >30 infants, whereas the rate of units caring for <10 neonates/day was highest in Spain (54%; 25/46).

Care Structure

Most units had either a team-based or a combination of a team-based and individual neonatologist-led care model, while a minority (15%; 49/325) had only an individual neonatologist-led care model (Table 1). The individual neonatologist-led care model was most common in Spain (35% of units; 16/46). Overall 55% of units (180/325) had an in-house neonatologist 24 h a day. This ranged from 30% of units in Australia-New Zealand (8/27) and Canada (9/30) to 100% (4/4) in Tuscany (Table 2). Fellows/subspecialty residents were available 24 h a day in 51% of units (164/325) and residents or junior doctors were available 24 h a day in 60% of all units (194/325). The presence of residents for 24 h a day varied substantially from 25% of units in Tuscany (1/4) to 96% in Australia-New Zealand (26/27). The presence of a respiratory therapist 24 h a day is a North American tradition reported in 93% of Canadian (28/30) and 100% of Illinoisan (15/15) units, but is rarely seen in other countries (Table 2).

Nurse-to-Patient Ratio

For patients who need complex critical care, the recommended 1:1 nurse-to-patient ratio was met by 52% of units (170/325); however, ≥90% of units in Australia-New Zealand, Canada, Finland, Illinois, and Sweden met recommendations (Table 3). Fifty-nine percent of units (192/325) met the recommended ≤1:2 nurse-to-patient ratio for neonates (1 nurse caring for 1 or 2 patients at the maximum) who were on multisystem support or needed intensive care, 86% (279/325) met the ≤1:3 nurse-to-patient ratio (1 nurse caring for 3 or fewer patients) recommendations for immediate care, and 62% (202/325) met the ≤1:4 nurse-to-patient ratio (1 nurse caring for 4 or fewer patients) requirements for continuing care.

Table 2. Healthcare worker availability for 24 h per day/7 days a week

	ANZNN (*n* = 27)	CNN (*n* = 30)	FinMBR (*n* = 5)	ILNN (*n* = 15)	INN (*n* = 26)	NRNJ (*n* = 155)	SEN1500 (*n* = 46)	SNN (*n* = 11)	SNQ (*n* = 6)	Tuscan NN (*n* = 4)	Total (*n* = 325)
Senior neonatologist	8 (30)	9 (30)	3 (60)	11 (73)	0 (0)	104 (67)	31 (67)	7 (64)	3 (50)	4 (100)	180 (55)
Fellow/subspecialty resident	12 (44)	15 (50)	1 (20)	8 (50)	3 (12)	93 (60)	23 (50)	5 (46)	3 (50)	1 (25)	164 (51)
Resident/junior doctor	26 (96)	16 (53)	2 (40)	7 (47)	22 (85)	73 (47)	33 (72)	10 (91)	4 (67)	1 (25)	194 (60)
Specialized nurse/nurse practitioner	11 (41)	5(17)	3 (60)	8 (53)	0 (0)	35 (23)	37 (80)	9 (82)	2 (33)	2 (50)	112 (35)
Respiratory therapist	0 (0)	28 (93)	0 (0)	15 (100)	3 (12)	1 (1)	1 (2)	1 (9)	0 (0)	0 (0)	49 (15)

Data are presented as *n* (%). ANZNN, Australia/New Zealand; CNN, Canada; FinMBR, Finland; ILNN, Illinois; INN, Israel; NRNJ, Japan; SEN1500, Spain; SNN, Switzerland; SNQ, Sweden; Tuscan NN, Tuscany; *n*, number of units in the network.

Table 3. Nurse to neonate ratio for various types of care needed

	Nurse: neonate ratio	ANZNN (*n* = 27)	CNN (*n* = 30)	FinMBR (*n* = 5)	ILNN (*n* = 15)	INN (*n* = 26)	NRNJ (*n* = 155)	SEN1500 (*n* = 46)	SNN (*n* = 11)	SNQ (*n* = 6)	Tuscan NN (*n* = 4)	Total (*n* = 325)
Unstable, complex critical care	1:1	26 (96)	28 (93)	5 (100)	15 (100)	5 (19)	50 (32)	27 (59)	10 (90)	3 (50)	1 (25)	170 (52)
Multisystem support	≤1:2	27 (100)	28 (93)	5 (100)	15 (100)	11 (44)	56 (36)	33 (71)	11 (100)	4 (67)	2 (50)	192 (59)
Intensive care	≤1:2	27 (100)	27 (90)	5 (100)	15 (100)	6 (23)	37 (24)	26 (57)	9 (80)	4 (67)	2 (50)	158 (49)
Intermediate care	≤1:3	21 (78)	22 (73)	4 (80)	11 (75)	26 (100)	144 (93)	43 (93)	10 (100)	5 (83)	3 (75)	279 (86)
Continuing care	≤1:4	19 (70)	9 (30)	3 (60)	2 (13)	23 (89)	87 (56)	42 (91)	10 (90)	4 (67)	3 (75)	202 (62)

Data are presented as *n* (%). ANZNN, Australia/New Zealand; CNN, Canada; FinMBR, Finland; ILNN, Illinois; INN, Israel; NRNJ, Japan; SEN1500, Spain; SNN, Switzerland; SNQ, Sweden; Tuscan NN, Tuscany; *n*, number of units in the network.

Availability of Medical Support Personnel

Pharmacists were present in 7% of units in Illinois during the day compared to 83% of units in Sweden (Table 4). Dietitians for the NICU were present in 22% of units in Japan compared to 83% of units in Sweden. Dedicated nurses for initial resuscitation were present in only 35% (113/325) of units including more than two-thirds of units in Canada, Illinois, and Sweden, and less than a quarter of units in Israel, Finland, Japan, and Tuscany. Social workers were present in 81% of units (263/325). Lactation consultants were available during weekdays in 45% (146/325) of units, including more than two-thirds of units in Australia-New Zealand, Canada, Illinois, Israel, Sweden, Switzerland, and Tuscany, but fewer than half of the units in Japan, Spain, and Finland. Parent buddies (6% of units) and parent support resources were available in only 11% of the units.

Discussion

Our large, international, multicenter survey identified a wide variation in the availability and organization of the healthcare professionals between and within countries. Variations were identified in the model of care delivery, availability of medical staff, level of nurse staffing, presence of nursing support, and availability of support staff.

To improve neonatal outcomes, a multidimensional focus including advanced use of medical technology, integration of families in care, and efficient teamwork between health professionals are recognized as the key to success [9]. Effective implementation of this strategy requires optimal availability of specialized healthcare professionals, resources, and organization [2, 10, 11]. The AAP recommends at least one in-house senior resident be present in the pediatric intensive care unit 24 h a day, 7 days a week, and similar recommendations are available for the adult ICU [12–14]. The British Association of Perinatal Medicine recommends the presence of a senior trainee and a junior trainee during out of hours for all NICUs. It also suggests an increase in staffing as the volume of activity increases. The NICUs providing >4,000 intensive care days per year are suggested to consider the presence of a consultant neonatologist 24 h a day, however it is not mandatory [15].

Previous studies described variable effects of in-house senior medical staff availability on neonatal outcomes.

Table 4. Availability of support personnel on weekdays

	ANZNN (n = 27)	CNN (n = 30)	FinMBR (n = 5)	ILNN (n = 15)	INN (n = 26)	NRNJ (n = 155)	SEN1500 (n = 46)	SNN (n = 11)	SNQ (n = 6)	Tuscan NN (n = 4)	Total (n = 325)
Specialized nursing support											
Dedicated nurses for resuscitation	15 (56)	22 (73)	1 (20)	11 (75)	6 (23)	33 (21)	13 (29)	7 (64)	4 (67)	1 (25)	113 (35)
Patient flow coordinator	21 (78)	20 (67)	4 (80)	14 (94)	4 (15)	53 (34)	12 (25)	6 (55)	5 (83)	1 (25)	140 (43)
Discharge coordinator	22 (82)	16 (53)	1 (20)	14 (94)	10 (39)	68 (44)	11 (24)	2 (18)	4 (67)	1 (25)	149 (46)
Quality officer/nurse	8 (30)	8 (27)	0 (0)	10 (69)	6 (23)	17 (11)	17 (36)	6 (55)	4 (67)	1 (25)	77 (24)
Safety officer/nurse	3 (11)	9 (30)	0 (0)	5 (31)	5 (19)	48 (31)	11 (24)	4 (36)	5 (83)	1 (25)	91 (28)
Nurse educator	25 (93)	27 (90)	2 (40)	13 (88)	12 (46)	36 (23)	15 (33)	7 (64)	4 (67)	1 (25)	142 (44)
Other support personnel											
Pharmacist	16 (59)	12 (40)	3 (60)	1 (7)	14 (54)	72 (46)	3 (7)	3 (27)	5 (83)	1 (25)	130 (40)
Dietitian	13 (48)	18 (60)	4 (80)	8 (53)	11 (42)	34 (22)	11 (24)	7 (64)	5 (83)	1 (25)	112 (34)
Social worker	27 (100)	27 (90)	3 (60)	15 (100)	23 (88)	115 (74)	37 (80)	9 (82)	5 (83)	2 (50)	263 (81)
Lactation consultant	23 (85)	20 (67)	1 (20)	13 (87)	19 (72)	31 (20)	22 (47)	9 (82)	4 (67)	4 (100)	146 (45)
Parent buddy	2 (7)	3 (10)	0 (0)	1 (6)	1 (4)	6 (4)	5 (10)	1 (9)	0 (0)	0 (0)	19 (6)
Parents' resource personnel	2 (7)	4 (13)	0 (0)	2 (13)	4 (15)	12 (8)	6 (13)	2 (18)	1 (17)	1 (25)	34 (11)

Data are presented as n (%). Some units also have availability on the weekend. ANZNN, Australia/New Zealand; CNN, Canada; FinMBR, Finland; ILNN, Illinois; INN, Israel; NRNJ, Japan; SEN1500, Spain; SNN, Switzerland; SNQ, Sweden; Tuscan NN, Tuscany; n, number of units in the network.

For example, Lee et al. [16] reported that neonates ≤32 weeks' gestation and admitted at night had a 60% higher mortality than neonates admitted during the day, and an in-house neonatal fellow or attending neonatologist at night may reduce the odds of mortality by half. Jensen and Lorch [17] concluded that very low birth weight neonates born between midnight and 7:00 a.m. are at higher risk for severe intraventricular hemorrhage and death or major neonatal morbidities. Lodha et al. [18] concluded that there was no significant difference in neurodevelopmental outcomes at 3 years corrected age following 24 h a day in-house coverage by a staff neonatologist; however, it was associated with a reduction in the duration of mechanical ventilation in extremely preterm neonates. Resnick et al. [19] reported that an after-hours in-house consultant neonatologist or neonatal fellow in the NICU until 11 p.m. showed no difference in outcomes of neonates <32 weeks' gestation. We identified variations in the availability of in-house neonatologists, fellows, and residents 24 h a day/7 days a week, similar to previous reports. For example, Denson and Adcock [20] reported that 47/204 (23%) NICUs in the USA had 24 h a day/7 days a week in-house neonatologist coverage. The complement of neonatologists in the department influences whether 24-h coverage is possible or not. Potential benefits of the presence of a neonatologist 24/7 could include the reduction of practice variability, reduction in certain adverse outcomes [21], and a shorter duration of hospitalization, which could reduce overall costs [22]. However, potential downsides include physician burnout [23] and difficulty recruiting neonatology trainees [22]. Continuous coverage can also hamper senior residents or fellows from becoming independent decision makers prior to becoming neonatologists [22].

The nurse-to-patient ratios in the NICU were defined by the AAP based on clinical acuity and the level of care needed [8]. Studies in the NICU have shown that a low nurse-to-patient ratio is associated with an increase in the risk-adjusted mortality [24, 25], mechanical ventilation adverse events [26], and nosocomial infections [27]. A study involving all 43 NICUs in the UK from the UK Neonatal Collaborative reported that increasing the nurse-to-patient ratio in tertiary NICUs was associated with decreased hospital mortality [28]. Hamilton et al. [29] reported that the survival of very low birth weight preterm neonates in the UK was related to the proportion of nurses with specialized neonatal qualifications per shift. A majority of units in our study met the AAP ratio requirements, however in some units this was not achieved. The association of nurse-to-patient ratios with outcomes needs further exploration.

Dedicated NICU pharmacists have a multidimensional role focused on rationalizing medication choice, adjusting doses, checking for drug interactions, reducing preventable adverse drug events [30], antimicrobial stewardship, and eliminating medication errors [30–32]. In our survey, we identified only 16% of units with a dedicated NICU pharmacist, similar to the adult literature

where only 23% of hospitals have pharmacists participating in the medical rounds [33]. Since there is no guideline for NICU pharmacist staffing, it is unknown whether it is associated with neonatal outcomes.

The American Society for Parenteral and Enteral Nutrition (ASPEN) and the European Society for Parenteral and Enteral Nutrition (ESPEN) recommended that NICUs have a dietitian/nutritionist as part of their team [34, 35]. When dietitians were present, preterm neonates had better weight gain, growth nutrition care score [36], and a shorter hospital stay [37]. Fenton et al. [38] surveyed 55 NICU and post-discharge services across Canada and identified that dietitians were involved in 73% of level 2 and 92% of level 3 units, with 71% providing follow-up care post-discharge. A survey involving 417 NICUs across the USA revealed that NICUs with full/part-time dietitians had a better mean nutrition care score in very low birth weight neonates than NICUs with no or limited dietitian involvement [36]. Thus, the presence of dietitians was associated with improved nutritional outcomes of preterm neonates; however, in our survey, marked variability was observed between and within countries.

Neonatal respiratory therapists play an important role in the multidisciplinary care of sick and preterm neonates [39]. However, this healthcare specialty is more (or exclusively) prevalent in North America but rare in other countries, which is evident in our results. In contrast to adults, limited data exist associating the presence of a respiratory therapist with respiratory outcomes in the NICU [40]. Genet et al. [39] reported that neonatal respiratory therapists improve staff satisfaction and the timelines of respiratory interventions.

Various organizations such as the World Health Organization and AAP [41, 42] have recommended the presence of certified lactation consultants to support mothers and help optimize breastfeeding. Castrucci et al. [43] reported higher breastfeeding rates (50%) among neonates in NICUs that had lactation consultants than in NICUs without (37%). A comparison of 2 epochs in a large NICU in Italy found that lactation consultants improved the exclusive breastfeeding rates at discharge from 21 to 51% [44]. Our survey identified that 45% of units have lactation support available in the NICU.

The availability of a specialized workforce like a patient flow coordinator, discharge coordinator, and nurses/individuals trained in safety, quality improvement, and education can also act as effective resources to manage patient flow, patient safety, and ultimately ensure the smooth functioning of the NICU [45]. In addition, the availability of social workers, parent buddy, and parents' resource personnel can help minimize social and moral stress among families in the NICU [9]. In our survey, we found a wide variability in the availability of support personnel across neonatal networks. The impact of support personnel on neonatal outcomes is unknown and difficult to prove.

The strengths of this report include a comparison of the availability of healthcare professionals in 10 networks and 11 high-income countries, including many aspects of person power that have not been well studied before, which provides an impetus to associate their availability with outcomes. However, there are some limitations of our report. First, the survey was limited to the units enrolled in the 10 networks and 11 high-income countries participating in iNeo, and did not include data from NICUs in the UK, France, China, India, or South American countries. Furthermore, networks such as the Vermont Oxford Network and the overwhelming majority of US NICUs are not included. Second, we asked clear-cut, yes or no questions, and it is possible that some of the professionals may be available in units on an ad-hoc or as-needed basis as well as some individuals possibly having dual qualifications, such as a nurse trained as a lactation consultant, or neonatologist trained in pharmacology. Third, we have not linked any of these data to outcomes of neonates; thus, we cannot associate the presence or absence of any group of professionals to outcomes. Fourth, there are limited data provided on the specialty level of care of the NICU (surgical care, referral center, birth hospital), which may affect the staff complement available 24 h a day. Finally, we have not considered the size of unit or presence of other units that sometimes share personnel, such as a pediatric intensive care unit.

However, our study provides important information that may be indirectly associated with neonatal outcomes. We anticipate that this information will stimulate further discussions on what services are appropriate to provide in the NICU. Future work should include evaluation of the impact of regional- and unit-level healthcare professionals' organization and availability on neonatal outcomes. These associations may lead to potentially better standards for the availability of healthcare professionals that every unit can implement to improve outcomes. We also believe that a systematic evaluation of available evidence to associate various staffing models and neonatal outcomes would identify the knowledge gaps in the field and help understand the reasons for the variability in health providers availability across the units.

Conclusions

We identified wide variations in the availability and organization of healthcare professionals and human resources between and within countries. Variations were mainly with respect to the model of care delivery, availability of nursing support, nursing staffing for various acuity scenarios, and availability of support staff structure. The association of the presence of professionals with neonatal outcomes is not well studied and further evaluation is recommended.

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Statement of Ethics

The data collection protocol was approved by the committee for human research, or equivalent, at the research institutions hosting all participating networks and local granting agencies as part of the protocol for collaborative comparisons of international health services and practices for quality improvement in neonatal care [6, 7]. Specific approval for this study protocol was obtained from the Research Ethics Board at Mount Sinai Hospital (Toronto, ON, Canada) where the project was coordinated.

Disclosure Statement

The authors have no conflicts of interest to declare.

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Author Contributions

P.S.S. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. M.S. and P.S.S. were responsible for the concept and design; data acquisition, analysis, and interpretation including statistical analysis; and drafting the manuscript. L.L., S.K.L., S.H., M.V., B.A.D., M.A., A.M., K.L., D.B., Na.M., Ne.M., A.N., S.K., M.B., K.H., T.I., and B.R. were responsible for data analysis, acquisition or interpretation, and critically reviewing the manuscript for important intellectual content. All authors have approved of the final version of the manuscript to be published and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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